Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Composite Satellite Overpasses OLYMPEX

Introduction

The GPM Ground Validation Composite Satellite Overpasses OLYMPEX dataset provides brightness temperature, precipitation, and total column water vapor estimates from multiple satellite overpasses including DMSP F16-19, GCOM-W1, GPM, MetOp, NOAA, and NPP for the OLYMPEX field campaign. The OLYMPEX field campaign took place between November, 2015, and January, 2016, with additional ground sampling continuing through February, on the Olympic Peninsula in the Pacific Northwest of the United States. This field campaign provides ground-based validation support of the findings resulting from the Global Precipitation Measurement (GPM) Core Observatory satellite. Data files are available from November 1, 2015 thru May 1, 2016 in HDF-5 format.

Citation

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Keywords:

NASA, GHRC, OLYMPEX, Washington, DMSP, F16, F17, F18, F19, GCOM-W1, GPM, MetOp-A, MetOp-B, NOAA-18, NOAA-19, NPP, SSMIS, AMSR2, DPR, GMI, MHS, ATMS, Ka, Ku, precipitation, total column water vapor, satellite overpass

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which launched on February 27, 2014. The instrument validation effort included numerous GPM-specific and joint

agency/international external field campaigns, using state of the art cloud and precipitation observational infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). Surface rainfall was measured by very dense rain gauge and disdrometer networks at various field campaign sites. These field campaigns accounted for the majority of the effort and resources expended by GPM GV. More information about the GPM mission is available at https://pmm.nasa.gov/GPM/.

One of the GPM Ground Validation field campaigns was the Olympic Mountains Experiment (OLYMPEX) which was held in the Pacific Northwest. The goal of OLYMPEX was to validate rain and snow measurements in mid-latitude frontal systems as they move from ocean to coast to mountains and to determine how remotely sensed measurements of precipitation by GPM can be applied to a range of hydrologic, weather forecasting, and climate data. The campaign consisted of a wide variety of ground instrumentation, radars, and airborne instrumentation monitoring oceanic storm systems as they approached and traversed the Peninsula and the Olympic Mountains. The OLYMPEX campaign was part of the development, evaluation, and improvement of GPM remote sensing precipitation algorithms. More information is available from the NASA GPM Ground Validation web site https://pmm.nasa.gov/olympex, and the University of Washington OLYMPEX web site http://olympex.atmos.washington.edu/.

Figure 1: OLYMPEX Domain
(Image Source: https://pmm.nasa.gov/OLYMPEX)

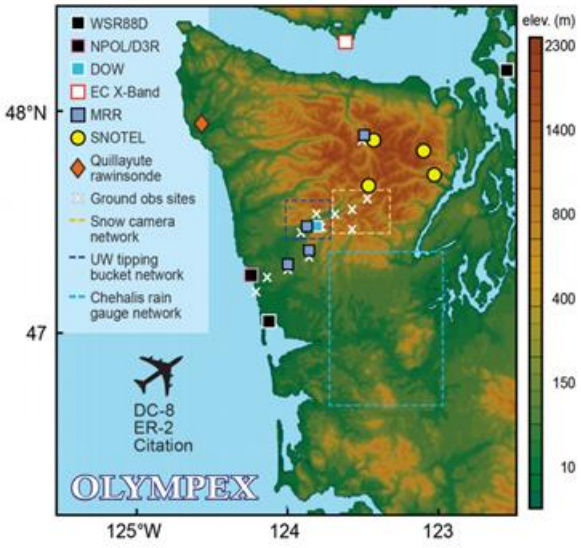

Figure 2: OLYMPEX Field Locations. The image does not contain ASO sampling region. (Image Source: https://pmm.nasa.gov/OLYMPEX)

Instruments and Satellites

MHS onboard the MetOp Satellites and the NOAA Satellites

The Microwave Humidity Sounder (MHS) is a self-calibrating, cross-track scanning, five-channel microwave, full-power radiometer, operating in the 89 to 190 GHz region. It is used to study profiles of atmospheric water vapor and provide improved input data to the cloud-clearing algorithms in Infrared (IR)/Microwave (MW) sounder suites. The MHS instruments were launched on NOAA's Polar Operational Environmental Satellites (POES) series starting with NOAA-18 launched in May 2005, continuing with NOAA-19 launched in February 2009.The European Space Agency's (ESA's) Meteorological Operational satellite programme (MetOp) series starting with MetOp-A launched in October 2006, continuing with MetOp-B launched in September 2012.

SSMIS onboard the DMSP F16-19

The Special Sensor Microwave Imager/Sounder (SSMIS) is able to estimate atmospheric temperature, moisture, and surface parameters from data collected at frequencies ranging from 19 to 183 GHz over a swath width of 1707 km. SSMIS is currently carried aboard Defense Meteorological Satellite Program (DMSP) F16, F17, F18 and F19 satellites.

GMI and DPR (Ku-band and Ka-band) onboard the GPM

The Core Observatory of the Global Precipitation Measurement (GPM) provides precipitation measurements from space. The primary instruments onboard the GPM Core Observatory are the GPM Microwave Imager (GMI) and the Dual-frequency Precipitation Radar (DPR). The GMI is characterized by thirteen microwave channels ranging in frequency from 10 GHz to 183 GHz. The DPR include a Ka-band 35 GHz frequency for

measuring ice precipitation and light rain and a Ku-band 14 GHz frequency for measuring heavy precipitation.

AMSR2 onboard the GCOM-W1

The Global Change Observation Mission – Water "Shizuku" (GCOM-W1) satellite was launched on May 17, 2012. The Advanced Microwave Scanning Radiometer 2 (AMSR2) instrument onboard the GCOM-W1 observes precipitation, water vapor, wind velocity above the ocean, sea water temperature, water levels on land areas, and snow depths.

ATMS onboard the NPP

The first Advanced Technology Microwave Sounder (ATMS) was launched on October 28, 2011 aboard the Suomi National Polar-orbiting Partnership (NPP) spacecraft. The ATMS instrument is the next generation cross-track microwave sounder providing atmospheric temperature and moisture for operational weather and climate applications. ATMS collects microwave radiation from the Earth's atmosphere and surface all day and all night, even through clouds.

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Data Characteristics

This GPM Ground Validation Composite Satellite Overpasses OLYMPEX dataset consists data files in HDF-5 format at Level 1 and Level 2 processing levels. More information about the NASA data processing levels are available on the NASA Data Processing Levels website. Table 1 lists the characteristics of this dataset.

Table 1: Data Characteristics

Characteristic	Description
Platforms	DMSP, GCOM-W1, GPM, MetOp, NOAA, NPP
Instruments	SSMIS (DMSP), AMSR2 (GCOM-W1), GMI and DPR (GPM), MHS (NOAA and MetOp), ATMS (NPP)
Projection	Equirectangular
Spatial Coverage	N: 57.463, S: 37.359, E: -88.423, W: -157.220
Spatial Resolution	5-17 km
Temporal Coverage	November 1, 2015 - May 1, 2016
Temporal Resolution	One file per orbit
Sampling Frequency	0.7-3 seconds
Parameter	Brightness temperature, precipitation, total column water vapor
Version	4
Processing Level	1, 2

File Naming Convention

This GPM Ground Validation Composite Satellite Overpasses OLYMPEX dataset consists of HDF-5 format data files. The files are named using the following convention:

Data files: [L1C|L2A|L2B]-CS-OLYMPEX.<sat>.<instr>.<algorithm>.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

Table 2: File naming convention variables

Variable	Description
L1C|L2A|L2B	Processing level *L1C = Level 1 for NASA processing level. The Level 1C products are common intercalibrated brightness temperature (Tc) products using the GPM Microwave Imager (GMI) as the reference standard. The GPM Level 1C algorithms transform equivalent Level 1B radiance data into Level 1C products. The input source data are geolocated and radiometric calibrated antenna temperature (Ta) or brightness temperature (Tb). *L2A, L2B = Level 2 for NASA processing level.
<sat>	Satellites: F16, F17, F18, F19, GCOMW1, GPM, METOPA, METOPB, NOAA18, NOAA19, NPP
<instr>	Instruments: SSMIS, AMSR2, DPR, GMI, DPRGMI, Ka, Ku, MHS, ATMS *described in instrument section above
<algorithm>	Processing algorithms: **XCAL2015-V**: Level 1C algorithm with satellite intercalibration table "XCAL2015-V" implemented **XCAL2015-C**: Level 1C algorithm with satellite intercalibration table "XCAL2015-C" implemented **GPROF2014v2-0**: Goddard Profiling Algorithm GPROF2014; Version 2 **V6-20160118**: GPM/DPR Level-2 Algorithm; Version 6 **CORRA2015**: Combined Radar-Radiometer Algorithm; 2015 version
YYYYMMDD	Start date: YYYY: Four-digit year MM: Two-digit month DD: Two-digit day
Shhmmss	Start time in UTC: hh: Two-digit hour mm: Two-digit minute ss: Two-digit second
Ehhmmss	End time in UTC:

	hh: Two-digit hour mm: Two-digit minute ss: Two-digit second
<###### >	Six-digit orbit number
V04A	Product version number
.HDF5	HDF-5 format

Data Format, Parameters and Algorithms

This GPM Ground Validation Composite Satellite Overpasses OLYMPEX dataset contains common calibrated brightness temperature, precipitation, and related science fields from passive microwave instruments flown on these satellites listed in Table 1. Data files are written in HDF-5 format.

A collection of 'Precipitation Retrieval Algorithms for GPM' publications can be found at https://journals.ametsoc.org/topic/gpm.

The following sections describe the structure and contents of these data files. More detailed information can be obtained from the File Specification for GPM Products.

(1) Level 1C common calibrated brightness temperature

The GPM Level 1C Algorithms transform equivalent Level 1B radiance data into Level 1C products (*NASA Level 1 processing level). The input source data are geolocated and radiometric calibrated antenna temperature (Ta) or brightness temperature (Tb). In the file naming convention, 'XCAL2015-V' represents Level 1C algorithm with satellite intercalibration table "XCAL2015-V" implemented, and 'XCAL2015-C' represents Level 1C algorithm with satellite intercalibration table "XCAL2015-C" implemented. All 1C products have a common L1C data structure, simple and generic. Each L1C swath includes scan time, latitude and longitude, scan status, quality, incidence angle, Sun glint angle, and the intercalibrated brightness temperature (Tc). One or more swaths are included in a product.

File Name: L1C-CS-OLYMPEX.[F16|F17|F18|F19].SSMIS.XCAL2015-V.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain common calibrated brightness temperature from the SSMIS passive microwave instruments flown on the DMSP F16-19 satellites. Swath S1 has 3 low frequency channels (19V 19H 22V). Swath S2 has 2 low frequency channels (37V 37H). Swath S3 has 4 high frequency channels (150H 183+/-1H 183+/-3H 183+/-7H). S4 has 2 high frequency channels (91V 91H). All the above frequencies are in GHz.

File Name: L1C-CS-OLYMPEX.GCOMW1.AMSR2.XCAL2015_V.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain common calibrated brightness temperature from the AMSR2 passive microwave instrument flown on the GCOM-W1 satellite. This products contains 6 swaths. Swath 1 has channels 10.65V 10.65H. Swath 2 has channels 18.7V 18.7H. Swath 3 has channels 23.8V 23.8H. Swath 4 has channels 36.5V 36.5H. Swath S5 has 2 high

frequency A-Scan channels (89V 89H). Swath S6 has 2 high frequency B-Scan channels (89V 89H). Data for all six swaths is observed in the same revolution of the instrument. High frequency A and high frequency B data are observed in separate feedhorns.

File Name: L1C-CS-OLYMPEX.GPM.GMI.XCAL2015_C.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain common calibrated brightness temperatures from the GMI passive microwave instrument flown on the GPM satellite. Swath S1 has 9 channels (10V 10H 19V 19H 23V 37V 37H 89V 89H). Swath S2 has 4 channels (166V 166H 183+/-3V 183+/-7V). Data for both swaths is observed in the same revolution of the instrument.

File Name: L1C-CS-OLYMPEX.[METOPA|METOPB|NOAA18|NOAA19].MHS.XCAL2015-V.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain common calibrated brightness temperature from the MHS passive microwave instrument flown on the NOAA and MetOp satellites. Swath S1 is the only swath and has 5 channels (89.0GHzV, 157.0GHzV, 183.31GHz+/-1GHzH, 183.31GHz+/-3GHzH, and 190.31GHzV). The scan period is 2.667s.

File Name: L1C-CS-OLYMPEX.NPP.ATMS.XCAL2015-V.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain common calibrated brightness temperature from the ATMS passive microwave instrument flown on the Suomi NPP satellite. ATMS rotates 3 scans per 8 seconds. ATMS has 22 channels. Each file contains 4 swaths. All 4 swaths contain observations sampled 96 times along the scan.

(2) Level 2A Radiometer Precipitation Profiling

File Name: L2A-CS-OLYMPEX.<sat>.<instr>.GPROF2014v2-0.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain surface rainfall and vertical hydrometeor profiles on a pixel by pixel basis generated from radiometer brightness temperature data using the Goddard Profiling algorithm GPROF2014 (Kummerow et al., 2015). The following passive microwave sensors are used: SSMIS onboard the DMSP F16 through F19, AMSR2 onboard the GCOM-W1, GMI onboard the GPM, MHS onboard the NOAA and MetOp, and ATMS onboard the NPP.

File Name: L2A-CS-OLYMPEX.GPM.[DPR|Ka|Ku].V6-20160118.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

These files contain precipitation estimates from the DPR on the GPM Core Observatory, retrieved using the GPM/DPR Level-2 Algorithm. There are three kinds of Level 2 algorithms for the DPR: DPR algorithm, Ku-only (KuPR) algorithm, and Ka-only (KaPR) algorithm. The latter two are single-frequency (SF) algorithms. The DPR algorithm is a dual-frequency (DF) algorithm.

The DPR Level-2A product is written as a 3 swath structure. The swaths are NS, normal scans, MS, matched scans, and HS, high sensitivity scans. The Ku Level-2A product is

written as a 1 swath structure. The swath is NS, normal scans. The Ka Level-2A product is written as a 2 swath structure. The first swath contains matched scans (MS), which are intended to be co-aligned with the Ku-band instantaneous fields of view (IFOV). The second swath contains the high-sensitivity scans (HS), which are interleaved between the Ku/Ku-MS swaths. Both swaths are narrow and centered within the interior of the Ku swath.

The retrievals are performed at each radar range bin along the slant path of the radar IFOV for each swath.

(3) Level 2B GPM DPR and GMI Combined Precipitation

File Name: L2B-CS-OLYMPEX.GPM.DPRGMI.CORRA2015.YYYYMMDD-Shhmmss-Ehhmmss.<######>.V04A.HDF5

This is the Level 2 DPR and GMI Combined precipitation product (Grecu et. al., 2016) that contains the data acquired by the Dual-Frequency Precipitation Radars and GMI flown on the GPM satellite in one orbit, or granule. It is written as a two-swath structure. The first swath, NS (normal scan), contains 49 rays per scan that match the KuPR rays. It is calculated from the KuPR and GMI data. The second swath, MS (matched scan), contains 25 rays per scan that match the 25 KaPR rays. It is calculated from the KuPR, KaPR, and GMI data.

Quality Assessment

The GPM L1C implementation uses GMI as the reference standard. For each sensor and satellite, an intercalibration table is implemented in the L1CXCAL algorithm to produce the intercalibrated brightness temperature (Tc). The final intercalibrated brightness temperature is Tc= Tb + offset. Please see the "Intercalibration of the GPM Microwave Radiometer Constellation" publication (Berg et al., 2016) for the physical and mathematical bases of satellite intercalibration.

To ensure the consistency among all L1C algorithms, all data are checked and quality flags (QFs) are assigned. L1C quality flags contain two sets of flags. The first set is the generic flags that apply to all sensors, and the second set is the sensor-specific flags that vary from sensor to sensor. Please refer to the GPM Level 1C Algorithms for more detailed information.

Software

The data files are self-describing HDF-5 format. Panoply can be used to easily view these HDF-5 data files.

Known Issues or Missing Data

Known gaps for these data can be found from the GPM spacecraft time or data gaps and anomalous events for previous (V04) data products and the PPS Partner Satellite Data Discrepancies Reports.

References

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Precipitation Retrieval Algorithms for GPM (https://journals.ametsoc.org/topic/gpm)

Related Data

All datasets from the OLYMPEX field campaign can be considered related to this Satellite Overpasses dataset. Other OLYMPEX campaign data can be located using the GHRC HyDRO 2.0 search tool, by entering the term 'OLYMPEX'.

Contact Information

To order these data or for further information, please contact:

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